PHYTOTOXICOLOGY ASSESSMENT SURVEY INVESTIGATION IN THE VICINITY OF CANADIAN INDUSTRIES LIMITED, COURTRIGHT - 1989

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Introduction

The Phytotoxicology Section of the Air Resources Branch has conducted vegetation assessment surveys in the vicinity of the Canadian Industries Limited (Lambton Works) superphosphate operation since the early 1970's. Substantial emissions of hydrogen fluoride (HF) have resulted from the manufacture of superphosphate fertilizer, the open stack of gypsum wastes and as a result of evaporation from two settling ponds east of the plant. Phytotoxicology field investigators have observed and documented injury to vegetation each year since 1972. Concerns regarding the HF emissions were initally raised because of injury to fluoride-sensitive terrestrial plants and the possible fluoride uptake by forage plant species (grasses) and subsequent ingestion of the HF-contaminated forage by livestock.

CIL initiated a de-commissioning plan to cap the large stack of gypsum waste material (over 15 metres in height and covering an area of approximately 40 hectares), with several feet of clay. As a result of this action, fluoride emissions from the stack source are expected to be eliminated. The capping program was completed in late summer, 1989.

With regard to the settling ponds, there are an estimated 500 million gallons of liquid contained within their confines. CIL has treated approximately 350 gallons with lime to remove phosphates and fluorides from the waste liquid and a further 100 million gallons are currently being treated.

Survey Design

The 1989 vegetation assessment survey was conducted in a similar fashion to those of 1983 to 1987. No survey activity was undertaken in 1988. Silver maple species were examined at each of 9 sites (Figure 1) in the vicinity of the CIL plant. At each site, duplicate samples of examined silver maple foliage were collected and placed in clean, new plastic sample bags.

At 10 other sites (Figure 2), also within close proximity to the CIL operation, duplicate samples of grasses only were collected in plastic bags for chemical analysis.

Both the silver maple foliage and grass samples were delivered to the Phytotoxicology vegetation processing laboratory in Toronto. Since both washed and unwashed analytical results were required of the maple foliage, each of the duplicate samples was divided in half - one-half to be processed as washed, the other as unwashed, according to established standard processing procedures. Grass samples were processed only as unwashed. Completed samples were submitted to the Ministry's Inorganic Trace Contaminants laboratory for total fluoride analysis.

Field Observations

Trace amounts (>0 - 1%) of fluoride-like injury were observed on silver maple foliage at survey site 1 - located north of the CIL settling ponds. Tissue injury consisted of dark brown necrosis restricted to the terminal portions of affected leaves. Leaves with typical injury symptoms were collected as herbarium specimens for inclusion in the survey file. No fluoride-like injury was observed on silver maple foliage at any of the remaining 8 sites.

Fluoride Analysis Results

Unwashed Silver Maple

Averaged fluoride results of the duplicate samples collected for the years between 1983 and 1989 have been assembled in Table 1. Shown at the base of the table is the Phytotoxicology upper limit of normal guideline for fluoride in unwashed rural foliage. The derivation of ULN's for contamination of vegetation is described in Appendix 1.

Fluoride concentrations in the 1989 unwashed maple foliage at the 3 sites closest to the CIL site (1, 6 and 11) were all much lower than in 1987 and 1986. The 3 site mean of 80 ppm in 1989 was the lowest since 1983 and considerably lower than the 352 ppm of 1987 and the 219 ppm of 1986. Nevertheless, fluoride concentrations in foliage at the 3 sites exceeded the Phyto ULN guideline of 15 ppm. This compares favourably with exceedences at 5 sites in 1987 and 6 sites in 1986.

Washed Silver Maple

Vegetation foliage collected for contaminant analysis is often washed to remove that fraction of the contaminant which may have been deposited in particulate form. This practice is commonplace where fluorides are the source of concern since normal fluoride content of soil in Ontario averages between 200 and 600 ppm. Re-entrainment of soil particles could lead to significant upward distortion of the analytical results. From a visual injury perspective, it is also considered more relevant to consider internal rather than external foliar contamination.

Fluoride values found in the washed sample portions of maple foliage collected during the 1989 vegetation are shown in Table 2. By comparing unwashed and washed results in tables 1 and 2, it is evident from their similarity, that little or no contamination due to fluoride particulates has occurred.

Unwashed Forage (Grasses)

Analysis results provide an indication of the extent and degree of fluoride contamination present in forage collected at the 10 collection sites established around the CIL property. Since there have been several instances during the past fifteen years when cattle have been grazed near the CIL works, particularly to the east, there has been concern about the possibility of fluorosis - a fluoride-induced disorder which affects the teeth and bones of cattle.

Concentrations of fluoride found in collected grasses from 1983 to 1989 have been assembled in Table 3. Shown at the base of the table is the Phyto ULN for unwashed rural forage and the 3 regulated limits for fluoride in forage.

With the exception of site 107 and 108, fluoride concentrations found in the 1989 forage at all other sample sites showed a sharp decline from those of 1987. The overall decline in 1989 values is evident in the all-site mean values shown at the base of Table 3. The all-site mean for 1989 was 18 ppm - lowest during the 1983-1989 period and half of the 1987 mean of 36 ppm.

With respect to the Phyto guideline, exceedences were noted at 3 sample locations in the 1989 forage. In 1987, exceedences were noted at 9 locations, at 8 in 1986 and at all 10 sites in 1984 and 1985.

The 3 recommended limits for fluoride are considered benchmarks for evaluating and determining the significance of the element in forage. These limits were set to protect cattle from fluorosis. No fluoride values in excess of the applicable limit (average for any 1 month) were found in forage at any of the 10 collection sites. Although much of the land around the site is owned by CIL, the company had agreed earlier, that their land would not be leased to local farmers for pasture or fodder production.

Summary

Vegetation assessment surveys were carried out in the vicinity of the Canadian Industries Limited Lambton Works in 1989. The survey design was unchanged from that followed during each of the previous sixteen survey years.

Trace (>0-1%) visible fluoride-like injury to silver maple foliage was only observed at site 1. In 1986 and 1987, trace to light injury was noted at sites 1 and 11.

With one exception, fluoride concentrations in the 1989 unwashed silver maple foliage at the 3 sites closest to CIL were the lowest since 1983. Values at all 3 sites exceeded the Phytotoxicology upper limit of normal guideline of 15 ppm.

Fluoride values found in both washed and unwashed silver maple foliage in 1989 were similar. This similarity indicates that no apparent contamination by fluoride-bearing particulate occurred.

With several exceptions, fluoride concentrations in 1989 forage samples were sharply lower than in 1986 and 1987. The decline which occurred in 1989 was reflected in the lowest all-site mean since 1983. None of the fluoride concentrations found in the 1989 forage exceeded the regulated limit for fluoride in forage of 80 ppm (average for any 1 month).

FIGURE: 1 Locations of 9 Silver Maple Surveillance Sites in the Vicinity of Canadian Industries Limited Lambton Works, Courtright

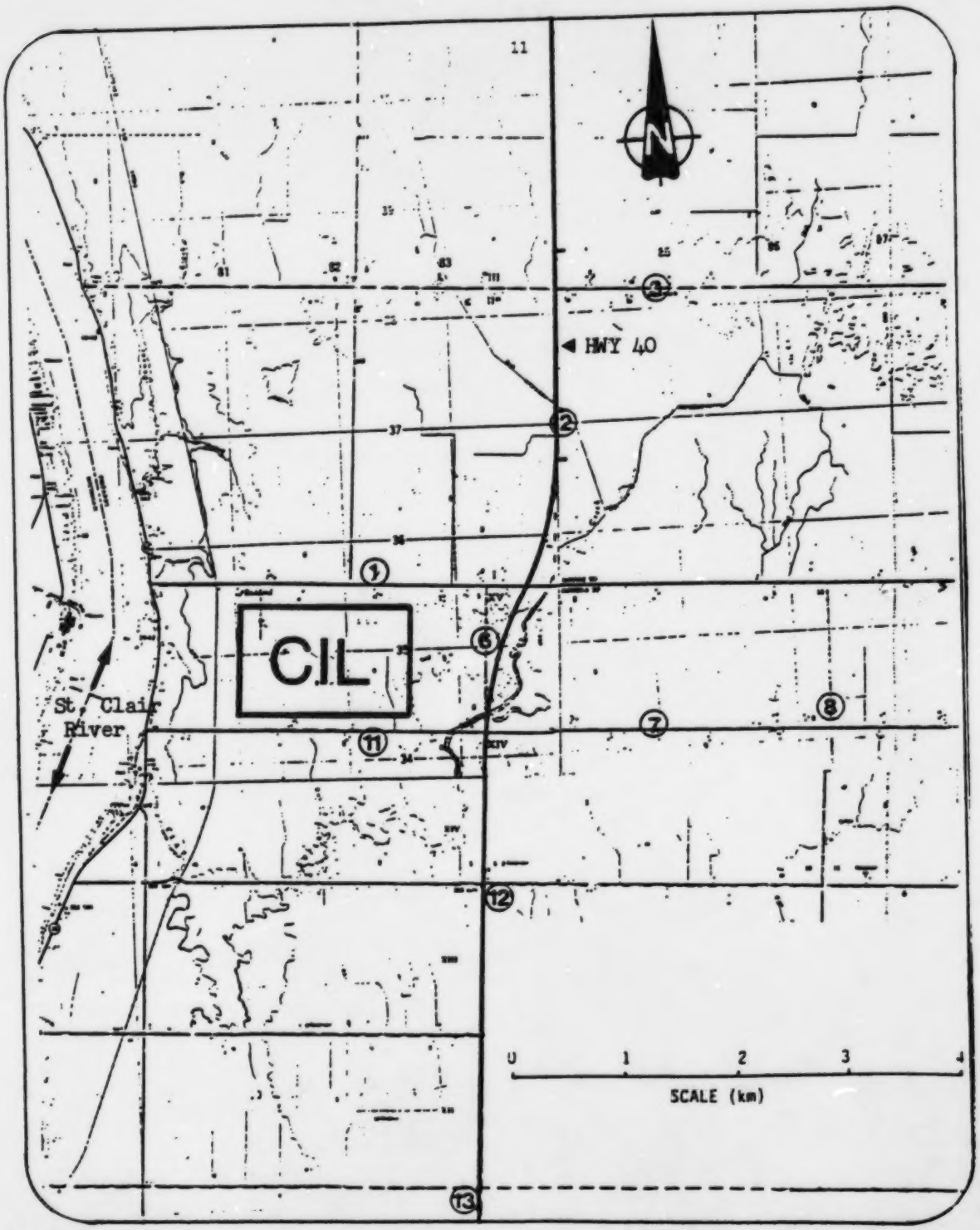
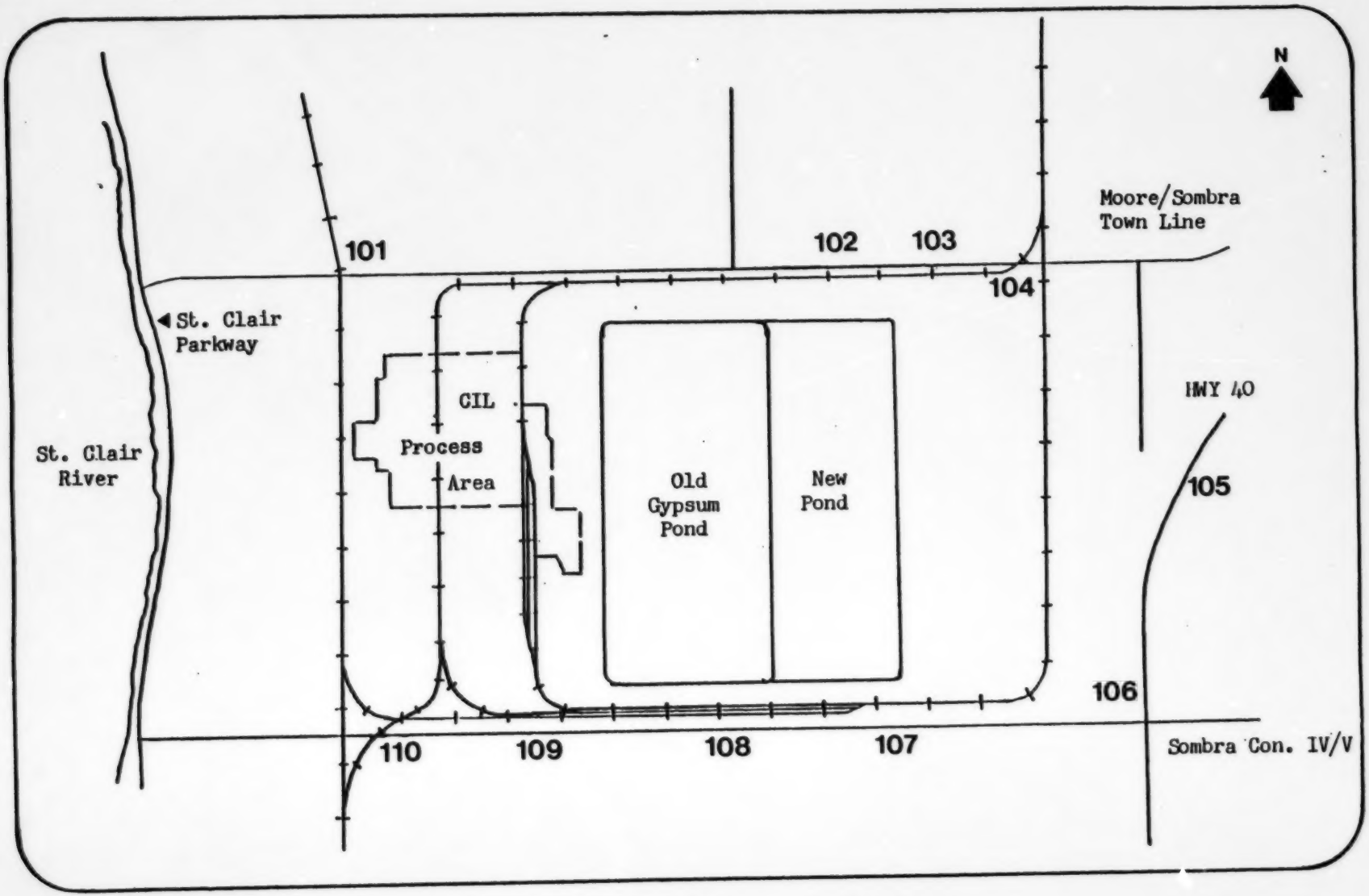


FIGURE: 2 Locations of 10 Grass Surveillance Sites in the Vicinity of the Canadian Industries Limited Lambton Works, Courtright



Approximate Scale: 1 cm = 170 metres

TABLE: 1 Fluoride Values[1] Found in Analyzed Unwashed Silver Maple Foliage Collected in the Vicinity of the CIL Lambton Works, Courtright

Sample Site Number	Approx. Distance & Direction from CIL	Fluoride Concentration (ppm - dry weight) 1983	1984	1985	1986	1987	1989
1	0.9 km NNE	337	668	464	435	670	160
2	3.0 km NNE	14	14	11	16	11	11
3	4.5 km NNE	17	12	14	12	15	10
6	1.4 km E	29	53	4	56	57	25
7	3.0 km E	19	15	9	16	12	13
8	4.5 km E	16	14	7	11	9	10
11	0.8 km SSE	84	101	160	165	330	55
12	2.6 km SSE	19	21	12	16	15	11
13	5.0 km S	13	12	8	12	7	9
Three Site Mean (1, 6 & 11)		**150**	**274**	**222**	**219**	**352**	**80**
Phyto Upper Limit of Normal for Fluoride in Unwashed Rural Foliage		**15**	**15**	**15**	**15**	**15**	**15**

[1]Mean value of duplicate sample analysis results.

TABLE: 2 **Fluoride Values[1] Found in Analyzed Washed Silver Maple Foliage Collected in the Vicinity of the CIL Lambton Works, Courtright**

Sample Site Number	Approx. Distance & Direction from CIL	Fluoride Concentration (ppm - dry weight) 1983	1984	1985	1986	1987	1989
1	0.9 km NNE	293	550	448	440	630	90
2	3.0 km NNE	10	12	9	12	12	9
3	4.5 km NNE	13	11	10	11	17	8
6	1.4 km E	19	43	29	49	40	21
7	3.0 km E	12	13	8	9	9	10
8	4.5 km E	10	12	5	9	8	10
11	0.8 km SSE	55	96	97	140	315	44
12	2.6 km SSE	12	15	9	13	12	10
13	5.0 km S	7	11	6	8	8	9
Three Site Mean (1, 6 & 11)		**122**	**230**	**191**	**210**	**328**	**52**

[1] Mean value of duplicate sample analysis results.

TABLE: 3 **Fluoride Values[1] Found in Analyzed Unwashed Grasses Collected at 10 Survey Sites in the Vicinity of CIL Lambton Works, Courtright 1983 - 1989[2]**

Forage Sample Site Number	Distance & Direction from CIL[3]	Fluoride Concentrations (ppm - dry weight) 1983	1984	1985	1986	1987	1989
101	765 m WNW[4]	11	21	8	6	14	5
102	250 m N	137	407	196	445	82	5
103	500 m ENE	23	48	76	80	89	9
104	850 m E	8	52	22	31	36	18
105	1300 m E	7	23	33	8	16	6
106	1000 m ESE	11	46	29	36	24	8
107	400 m ESE	24	151	127	105	36	56
108	200 m E	40	189	104	95	27	27
109	300 m SW	8	85	63	88	23	12
110	700 m WSW	3	21	29	17	9	5
All Site Mean		27	104	69	91	36	18
Phytotoxicology ULN Guideline for grasses		12	12	12	12	12	12
Recommended Limits for Fluoride in Forage		35[5] 60[6] 80[7]	35 60 80	35 60 80	35 60 80	35 60 80	35 60 80

[1] Mean values of duplicate sample analysis results.

[2] No survey was conducted in 1988. [3] Distance from old settling pond.

[4] Distance from CIL ammonia complex. [5] Growing season average.

[6] Average for any 2 consecutive months. [6] Average for any 1 month.

Appendix I

Derivation and Significance of MOE "Upper Limits of Normal" Contaminant Guidelines

The MOE "upper limits of normal" contaminant guidelines essentially represent the expected maxiumum concentration of contaminants in surface soil (non-agricultural), foliage (tree and shrub), grass, moss bags and/or snow from areas of Ontario not subject to the influence of point sources of emissions. "Urban" guidelines are based upon samples collected from centers of minimum 10,000 population. "Rural" guidelines are based upon samples collected by MOE personnel using standard sampling techniques (ref: Ministry of the Environment, 1983. Field Investigation Manual. Phytotoxicology Section - Air Resources Branch: Technical Support Sections - NE and NW Regions). Chemical analyses were performed by the MOE Laboratory Services Branch.

The guidelines were calculated by taking the arithmetic mean of available analytical data and adding three standard deviations of the mean. For those distribution that are "normal", 99% of all contaminant levels in samples from "background" locations (i.e. not affected by point sources nor agricultural activities) will lie below these upper limits of normal. For those distributions that are non-normal, the calculated upper limits of normal will not actually equal the 99th percentile, but nevertheless they lie within the observed upper range of MOE results for Ontario samples.

Due to the large variability in element concentrations which may be present across Ontario, even in background data, control samples should always be collected. This is particularly important for soils, which show large regional variations in element composition due to difference in parent material. Species of vegetation which naturally accumulate high levels of an element also may be encountered.

It is stressed that these guidelines do not represent maximum desirable or allowable levels of contaminants. Rather, they serve as levels which, if exceeded, would prompt further investigation on a case by case basis to determine the significance, if any, of the above normal concentration(s). Concentrations which exceed the guidelines are not necessarily toxic to plants, animals or man. Concentrations which are below the guidelines are not known to be toxic.